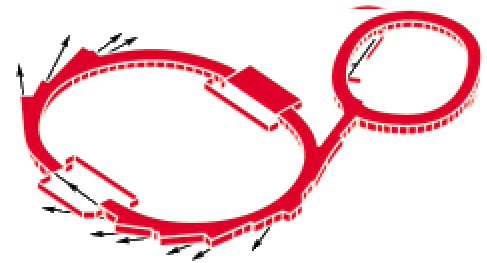
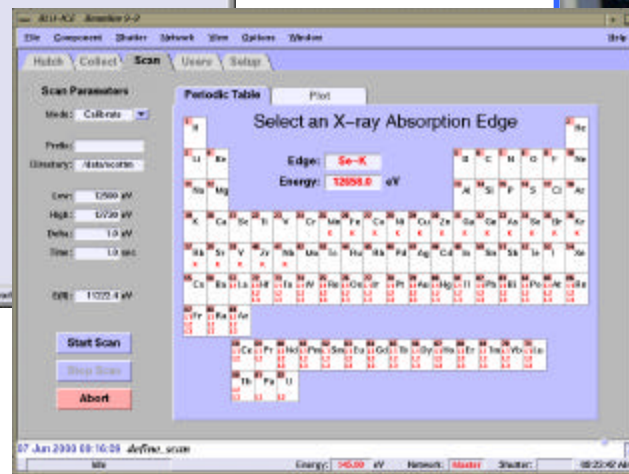
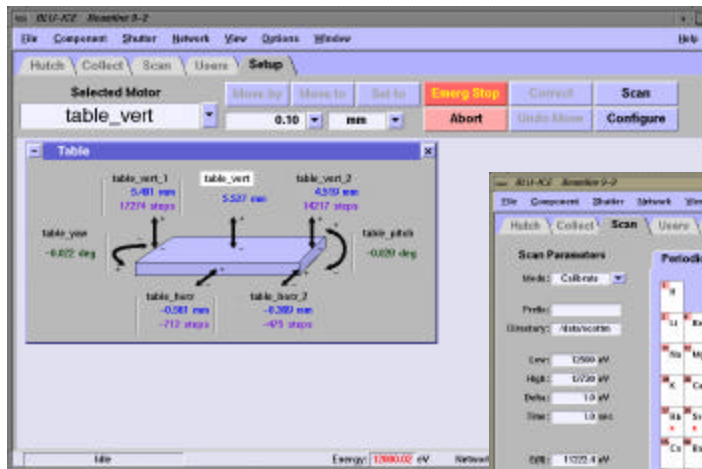




NOBUGS III
Daresbury Laboratory
June 12, 2000



BLU-ICE and the Distributed Control System



*S. McPhillips, Stanford Synchrotron Radiation Laboratory, scottm@slac.stanford.edu
SSRL is funded by the US Dept. of Energy and the National Institutes of Health*

Overview



- **BLU-ICE**
 - GUI Building Philosophy
 - Features of the Graphical User Interface
 - Powerful Member of a Collaboratory

- **Distributed Control System Architecture**
 - Control Message Life Cycle
 - Architecture of the Distributed Software Components
 - BLU-ICE
 - Distributed Hardware Servers
 - Distributed Control System Server

- **Conclusions on Distributed System Development**
 - XOS and Cross Platform Development
 - Software Development Tools

BLU-ICE Experimental Setup Window



BLU-ICE Beamline 9-2

File Component Shutter Network View Options Window Help

Hutch Collect Scan Users Setup

Goniometer

Omega: 0.000 deg
Phi: 107.000 deg
Kappa: 0.000 deg

I_0 : 0
Attenuator
Beam Size
 I : 0
Shutter

% Transmittance: 100.000 %
Horiz: 200 μ m
Vert: 200 μ m

Energy: 16000.03 eV
Sample Fluorescence: 0
Re-optimize Beam

Detector
Vertical: 46 mm
Distance: 70.000 mm
Horizontal: -47 mm
ADSC Q-4

Translate Crystal

-90 Phi +90

Max Res @ Detector

0.74Å, 0.67Å, 1.34Å
Mosflm/Denzo beam x 140.0 y 47.0

Apply Cancel Abort

Idle Energy: 16000.03 eV Network: Slave Shutter: Closed 10:24:59 AM

BLU-ICE Data Collection Control



BLU-ICE Beamline 8-2

File Component Shutter Network View Options Window

Hutch Collect Scan Users Setup

/data/peter/n9/g4071_17/n9_gs4071_17_1_100.img

Snap
Pause
Abort

Current Position
Phi: 69.49
Omega: 0.00
Kappa: 0.00
Distance: 70.00

Run Sequence

mn1089_1_330	141.50
mn1089_1_331	142.00
mn1089_1_332	142.50
mn1089_1_333	143.00
mn1089_1_334	143.50
mn1089_1_335	144.00
mn1089_1_336	144.50
mn1089_1_337	145.00
mn1089_1_338	145.50
mn1089_1_339	146.00
mn1089_1_340	146.50
mn1089_1_341	147.00
mn1089_1_342	147.50
mn1089_1_343	148.00
mn1089_1_344	148.50
mn1089_1_345	149.00
mn1089_1_346	149.50
mn1089_1_347	150.00
mn1089_1_348	150.50
mn1089_1_349	151.00
mn1089_1_350	151.50
mn1089_1_351	152.00
mn1089_1_352	152.50
mn1089_1_353	153.00
mn1089_1_354	153.50
mn1089_1_355	154.00
mn1089_1_356	154.50
mn1089_1_357	155.00
mn1089_1_358	155.50
mn1089_1_359	156.00
mn1089_1_360	156.50

*COMPLETE

Run 1 (complete)
0
1
Default Update Delete Reset

Prefix: mn1080
Directory: /data/olmstead/mn1080
CCD Mode: slow
Distance: 70.000 mm
Axis: phi
Delta: 0.50 deg
Time: 1.0 sec

Frame phi
Start: 001 337.00 deg
End: 380 517.00 deg
Inverse Beam: (phi axis vert)
Wedge: 180.0 deg
Energy: 16000.03 eV

Contrast 2400 Zoom 1.40

Exposing dark_0.im0... Energy: 16000.03 eV Network: Slave Shutter: Closed 10:21:42 AM

BLU-ICE Beam Line Configuration Window



The screenshot displays the BLU-ICE Beamline 9-2 configuration window. The interface includes a menu bar (File, Component, Shutter, Network, View, Options, Window, Help) and a toolbar with buttons for 'Move by', 'Move to', 'Set to', 'Emerg Stop', 'Correct', 'Scan', 'Abort', 'Undo Move', and 'Configure'. The 'Selected Motor' field is currently empty.

Two main configuration panels are visible:

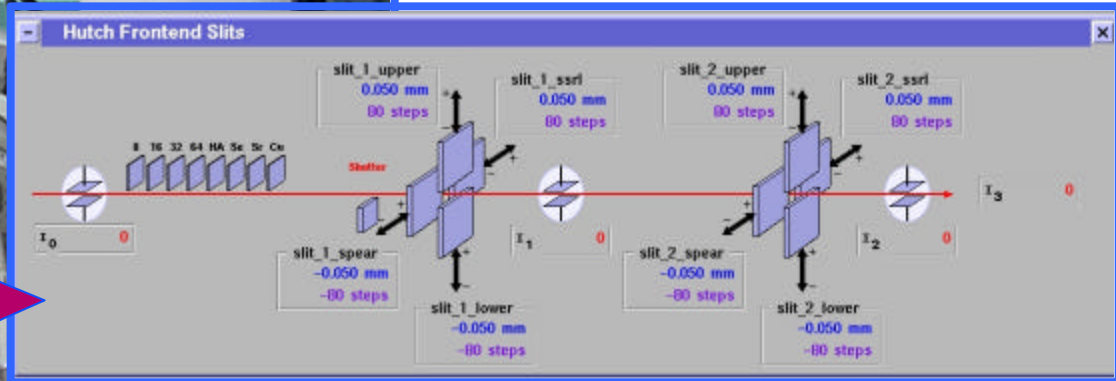
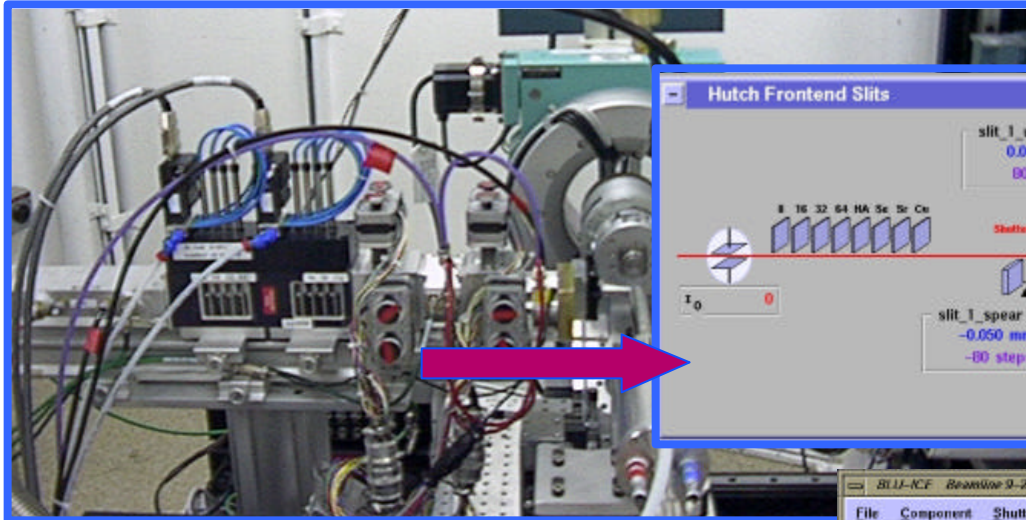
- Mirror:** Shows a schematic of a mirror assembly with the following parameters:
 - mirror_slit_upper: -1.141 mm, -100 steps
 - mirror_slit_lower: -4.621 mm, -729 steps
 - mirror_vert: -0.878 mm, -1075 steps
 - mirror_pitch: 0.228 deg, 3263 steps
 - mirror_bend: 1.155 mm, 1276 steps
- Monochromator:** Shows a schematic of a monochromator assembly with the following parameters:
 - mono_slit_vert: 14.378 mm, 2212 steps
 - mono_slit_ssr1: 3.003 mm, 473 steps
 - mono_slit_spear: -6.006 mm, -946 steps
 - mono_slit_lower: -32.000 mm, -2512 steps
 - mono_roll: 0.000 deg, 0 steps
 - mono_pitch: 0.000 deg, 0 steps
 - mono_theta: 7.098 deg, 141960 steps
 - energy: 16000.03 eV

A console window at the bottom displays the following log messages:

```
20 Apr 2000 10:29:26 NOTE: Data collection stopped.
20 Apr 2000 10:29:26 NOTE: stog_motor_move_completed gonio_phi 108.947200 aborted
20 Apr 2000 10:29:26 ERROR: Move of motor gonio_phi was aborted.
20 Apr 2000 10:29:26 NOTE: Reading out mn1080_0_003.img...
20 Apr 2000 10:29:27 NOTE: Shutter shutter closed.
20 Apr 2000 10:29:44 NOTE: Loading /data/olmstead/mn1080/mn1080_0_003.img...
```

The status bar at the bottom indicates: Idle | Energy: 16000.03 eV | Network: Slave | Shutter: Closed | 10:30:08 AM

GUI Building Philosophy



Define Scan

File Options

Scan Axes

Axis	Points	Start	End	Step	Units
energy	41	12500	12730	3.5	eV
(none)					

Detectors

Signal: *i_sample*
Reference: *i1*

Repeat

Number of scans: 1
Delay between scans: 0 min

Timing

Integration time: 1.0 sec
Motor settling time: 0.0 sec

Files

Filename root: *se_edge*
Scan Number: 1

Filters

- HA Cu Al_32
- Se Al_B Al_64
- Sr Al_16

Start Scan

Scan Parameters

Mode: Calibrate
Prefix:
Directory: /data/scottn

Low: 12500 eV
High: 12730 eV
Delta: 1.0 eV
Time: 1.0 sec

E[0]: 11222.4 eV

Start Scan
Stop Scan
Abort

Periodic Table

Select an X-ray Absorption Edge

Edge: **Se-K**
Energy: **12658.0 eV**

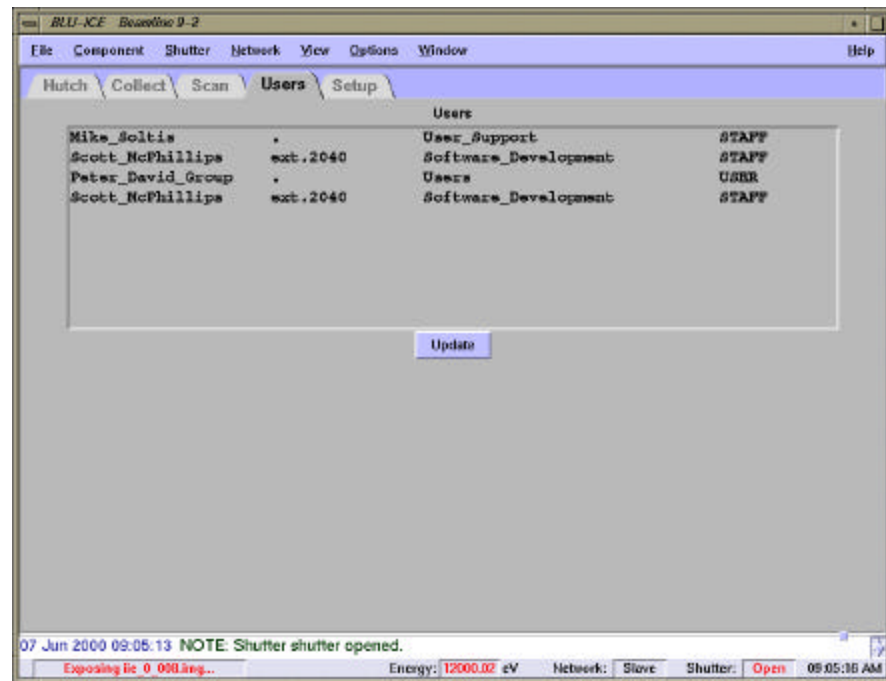
07 Jun 2000 09:16:09 *define_scan*

Idle Energy: 145.00 eV Network: Master Shutter: 09:23:42 AM

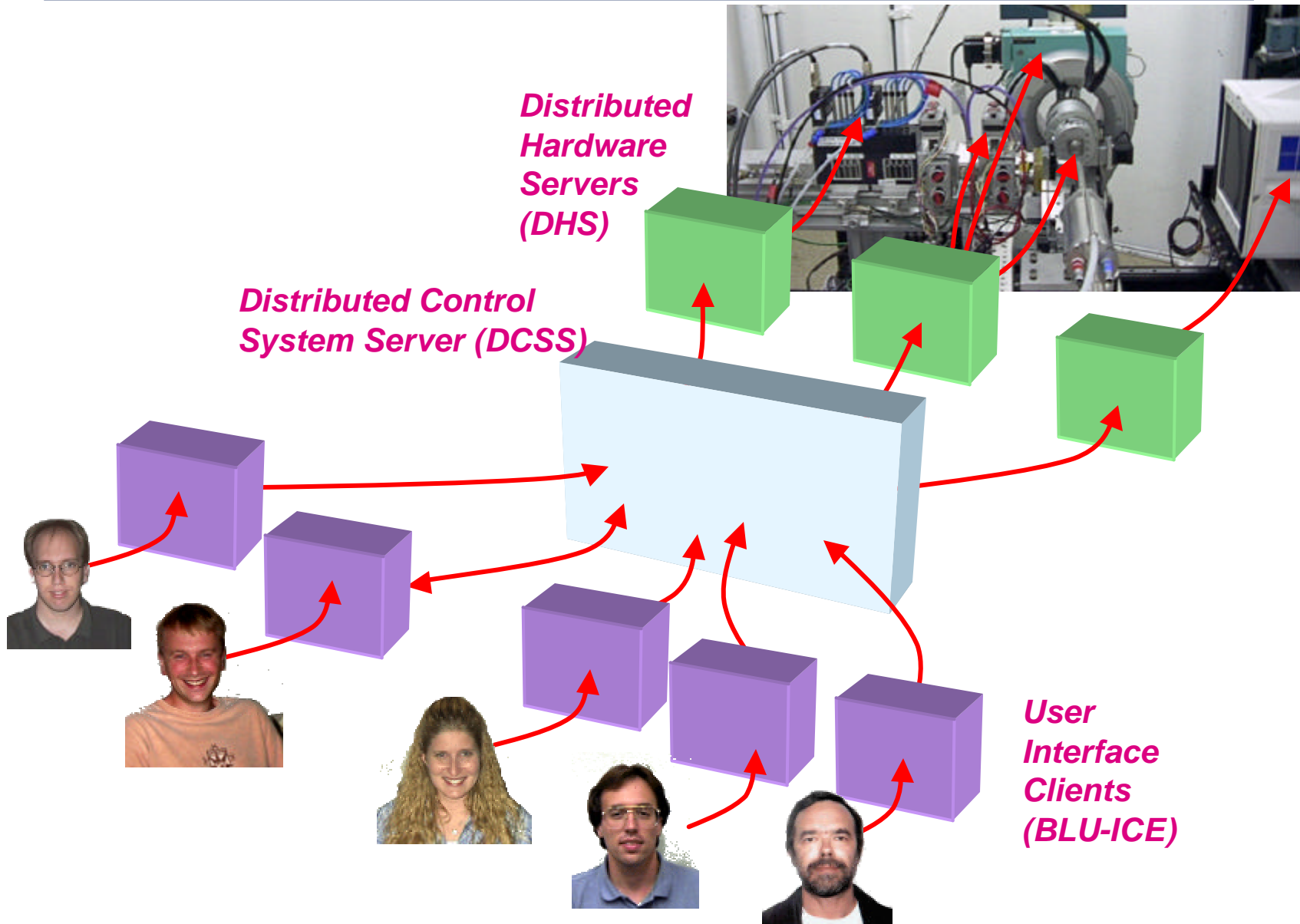
BLU-ICE Collaboration Features



- Multiple GUI clients active simultaneously.
- Connection can be broken with server without affecting data collection.
- All GUI clients are synchronized.
- “Users” window shows other BLU-ICE clients currently connected.



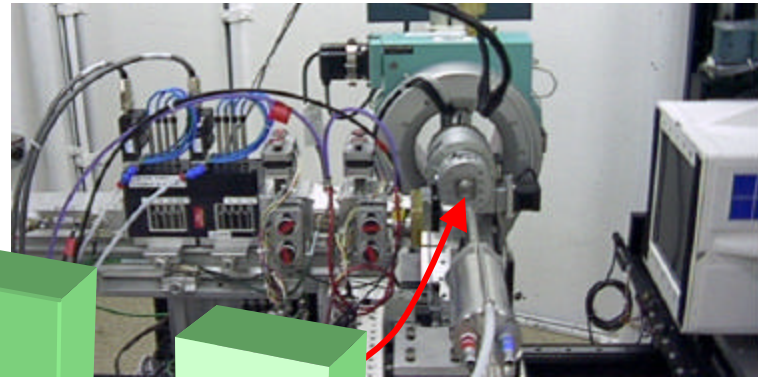
Architecture of the Distributed Control System



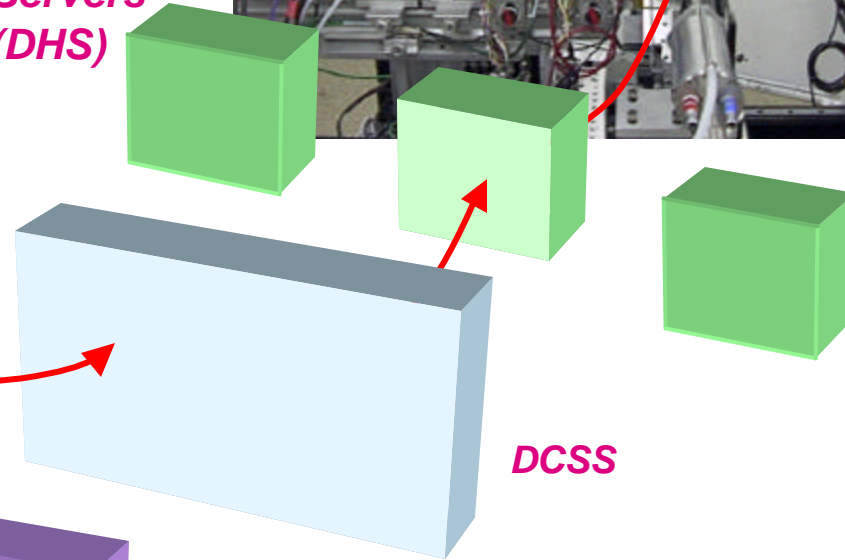
Life Cycle of a Control Command



- User issues a move command for a specific motor (e.g. ϕ).
- DCSS receives command and forwards to the DHS responsible for motor of interest.
- DHS handles hardware controller.
- Motor begins motion.

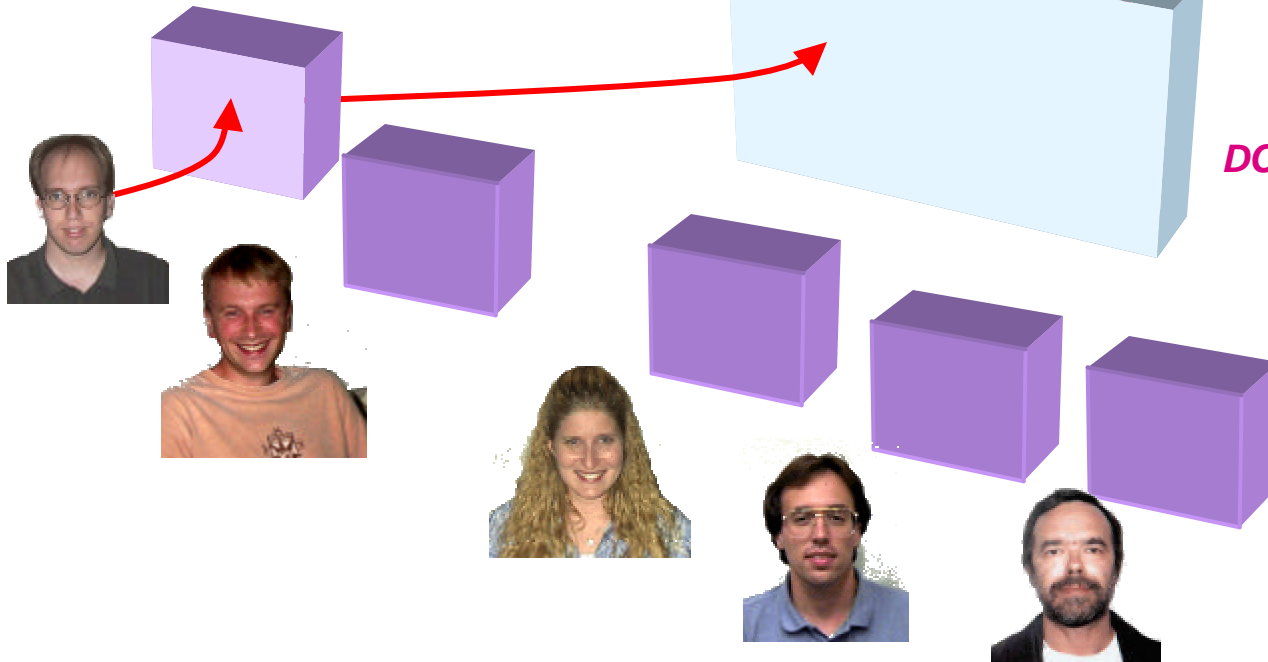


Distributed Hardware Servers (DHS)



DCSS

User Interface Clients (BLU-ICE)

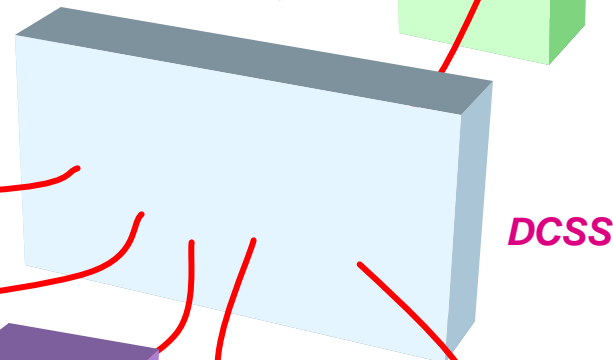
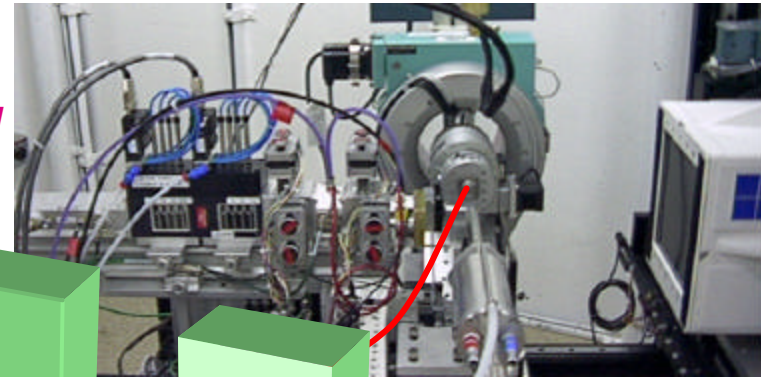


Response to Control Command



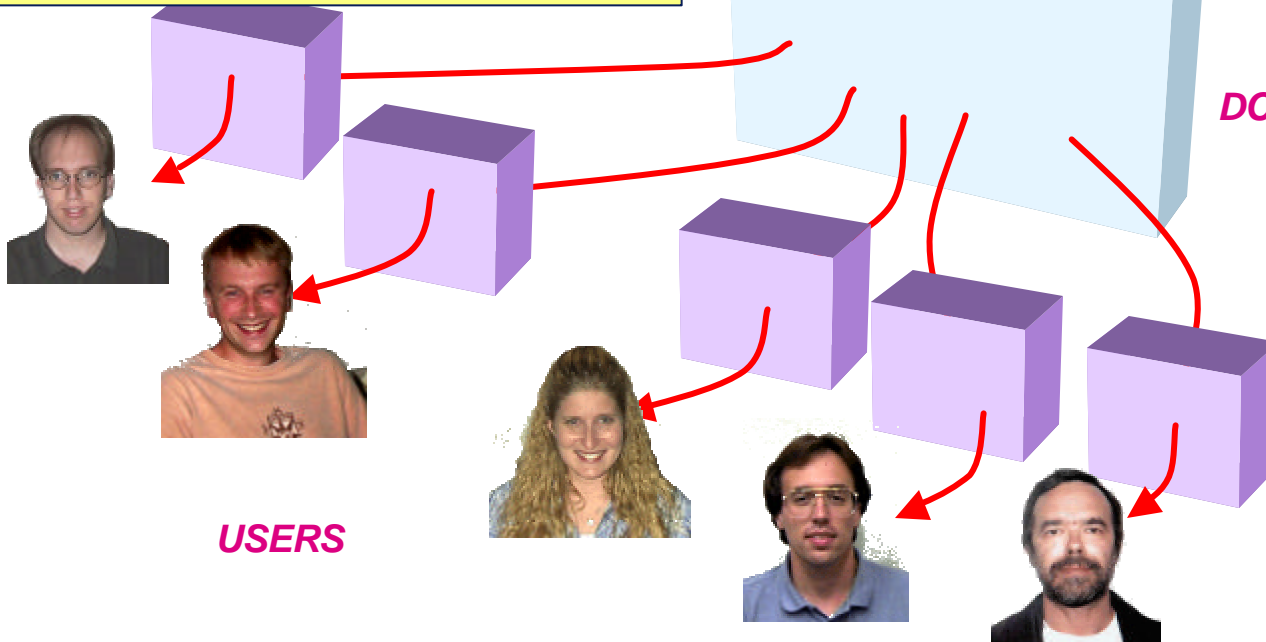
- DHS polls motor position (e.g. ϕ) and sends messages to DCSS.
- DCSS receives these messages and forwards the new motor positions to all user interface clients.
- All users see current motor position as it moves.
- The polling continues until motor stops moving.

Distributed Hardware Servers (DHS)



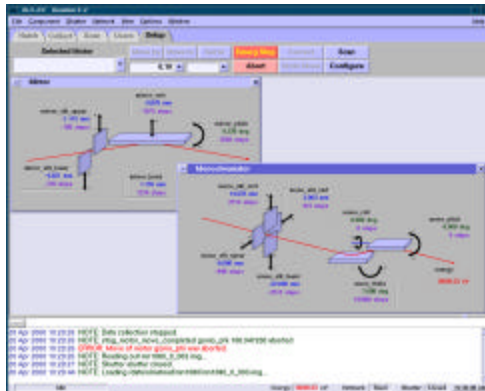
DCSS

User Interface Clients (BLU-ICE)



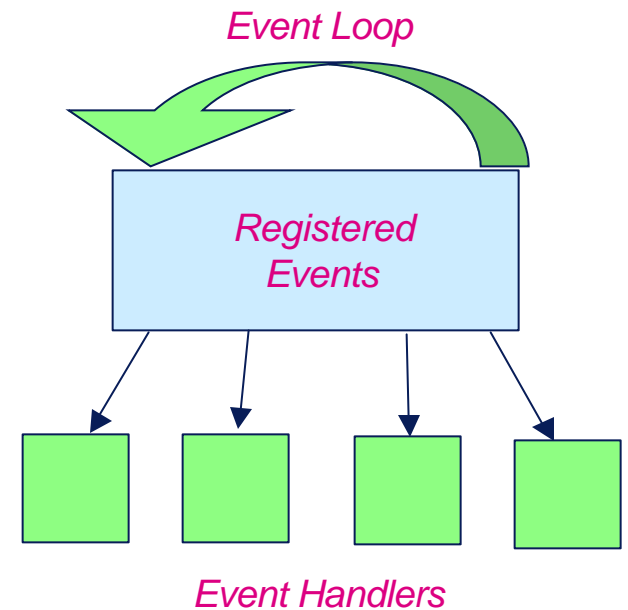
USERS

BLU-ICE and TCL



- **TCL Features**
 - Cross platform
 - Typeless (Simplifies Code!)
 - Reusable Code
 - Many GUI extensions (TK)
 - Rapid development features support rapid beam line changes

- **TCL is An Event Driven Language**
 - One execution stream
 - One registers interest in events
 - wait for button to be pushed
 - wait for motor to stop moving
 - Built-in event loop waits for events and invokes handlers
- **Scripts can be dynamically loaded to control hardware sequences**
 - No compilation necessary
 - Scripts executed from BLU-ICE command prompt.



Distributed Hardware Server and XOS



- **Features**
 - Multi-threaded, handles multiple hardware controllers
 - C/C++ for high speed
 - Cross-platform code allows integration of platform-specific API's

- **XOS library for portable code**
 - Wraps system calls in portable library code
 - Network communication
 - Thread creation
 - Memory mapped files
 - Inter-thread communication
 - Portability
 - Compile code on Digital Unix, IRIX, OpenVMS, Windows NT/95.
 - Easy to port to new platforms similar to any of the above.
 - Reliability
 - Simpler APIs leads to more reliable code.
 - Less need to study different platforms.
 - Performance
 - Native system calls on each platform for maximum performance
 - No runtime overhead for platform independence.

- **Easy to support new API, regardless of platform**



Current Hardware Support

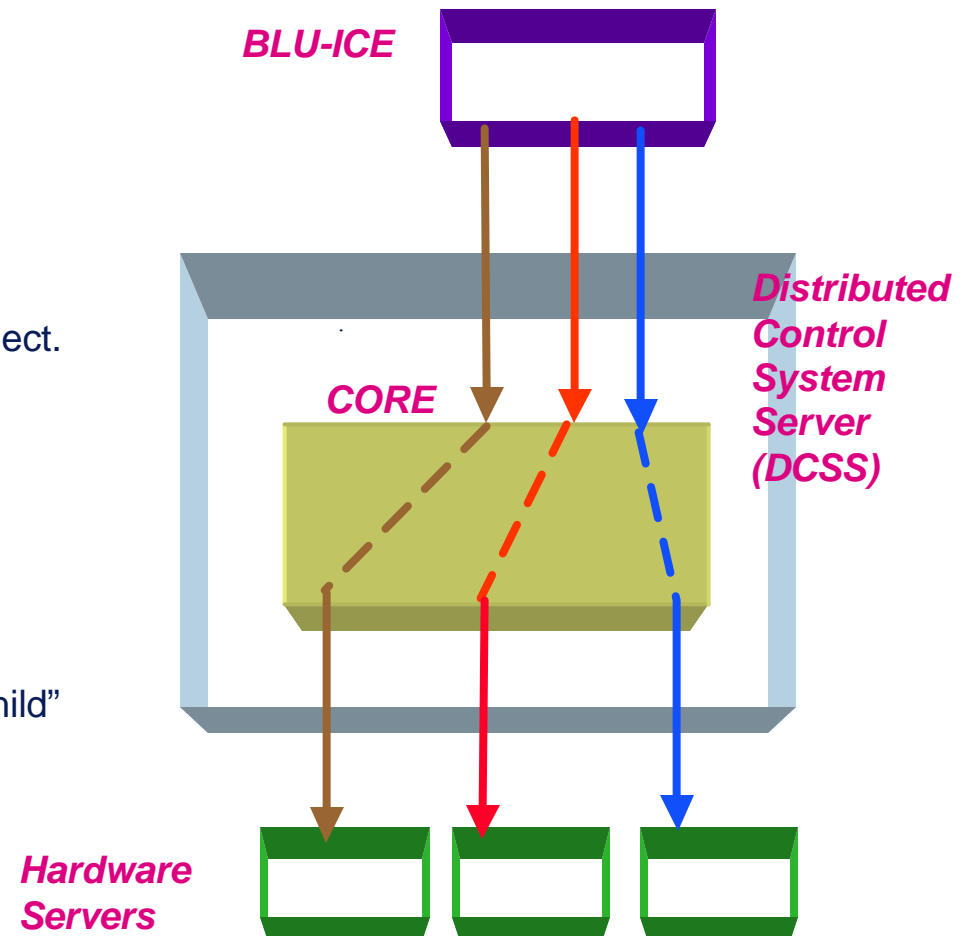


Controller Type	Function	Operating System	Controller Bus	Comments
DMC1000	Motion Control	Windows NT	ISA	3 rd Party API
DMC2180	Motion Control	Cross Platform	Ethernet Based	Ported from Windows NT
SSRL Control System (ICS)	Motion Control	VMS	CAMAC	Wraps ICS
Quantum 4 CCD	Detector	Cross Platform		
MAR345	Detector	UNIX		Uses scan345
MOXA2000	N/A	Cross Platform	RS232-to-ethernet converter	Heidenhain encoder
SIMULATION	Simulates motion control (no physical motors)	Cross Platform	N/A	Useful for testing code at user interface or DCSS level

Distributed Control System Server (DCSS)



- **C/C++ with XOS library**
 - Cross platform.
- **Multi-threaded**
 - Multiple GUI clients.
 - Multiple hardware servers.
- **Security and Privilege Checking**
 - Unauthorized GUI clients cannot connect.
 - GUI commands have privilege requirements.
 - Users have privilege levels.
- **Memory Mapped File**
 - stores current motor positions.
- **Supports Scripted Devices**
 - Scripted devices can have “parent / child” relationships.
 - Scripts are written in TCL.



Scripted Devices: Path of a Control Message

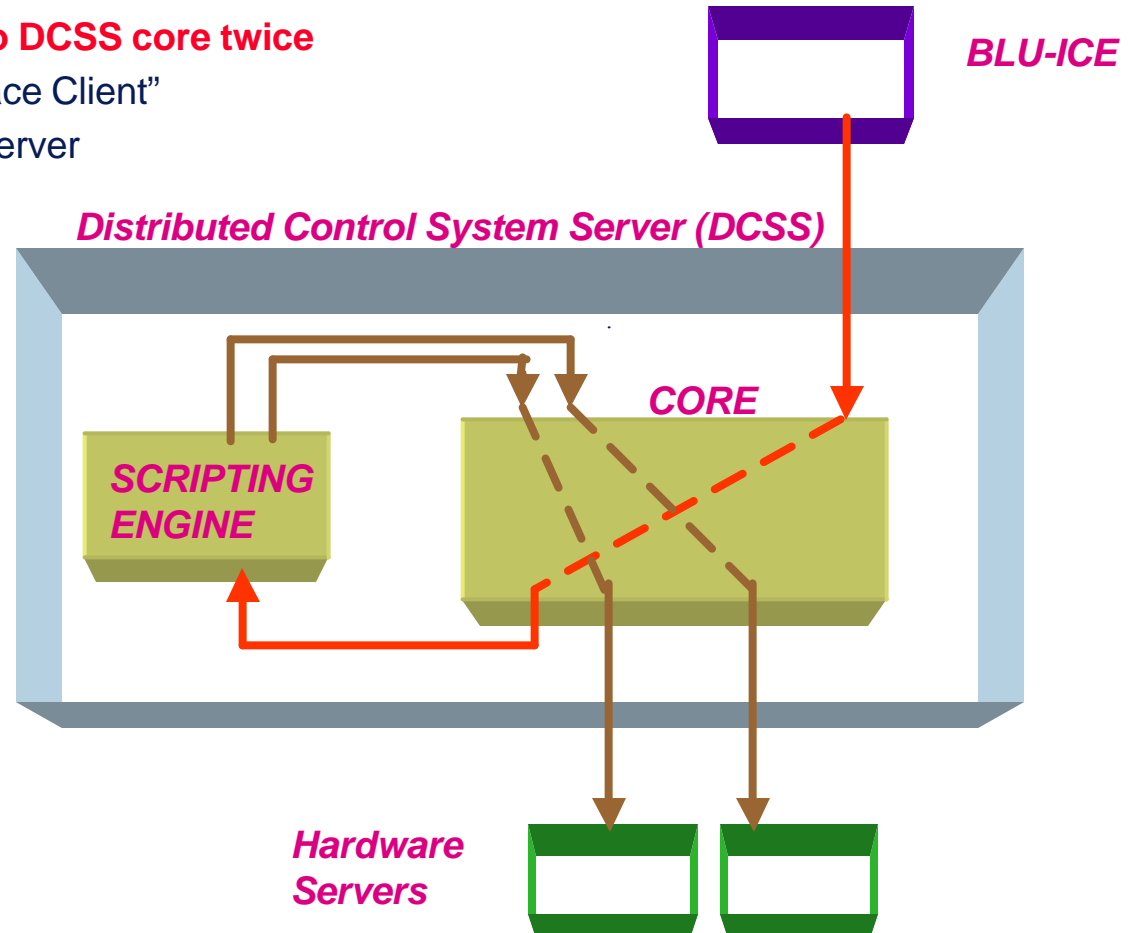


- **Scripting Engine connects to DCSS core twice**
 - Connects as “User Interface Client”
 - Connects as Hardware Server

- **Scripted Device Command Message Routing**

- Request from BLU-ICE to move parent motor is routed to Scripting Engine.
- Scripting Engine sends two messages to Core, requesting move of two motors.
- Core DCSS forwards message to external DHS.

- **Children motors may also be scripted devices with their own children.**



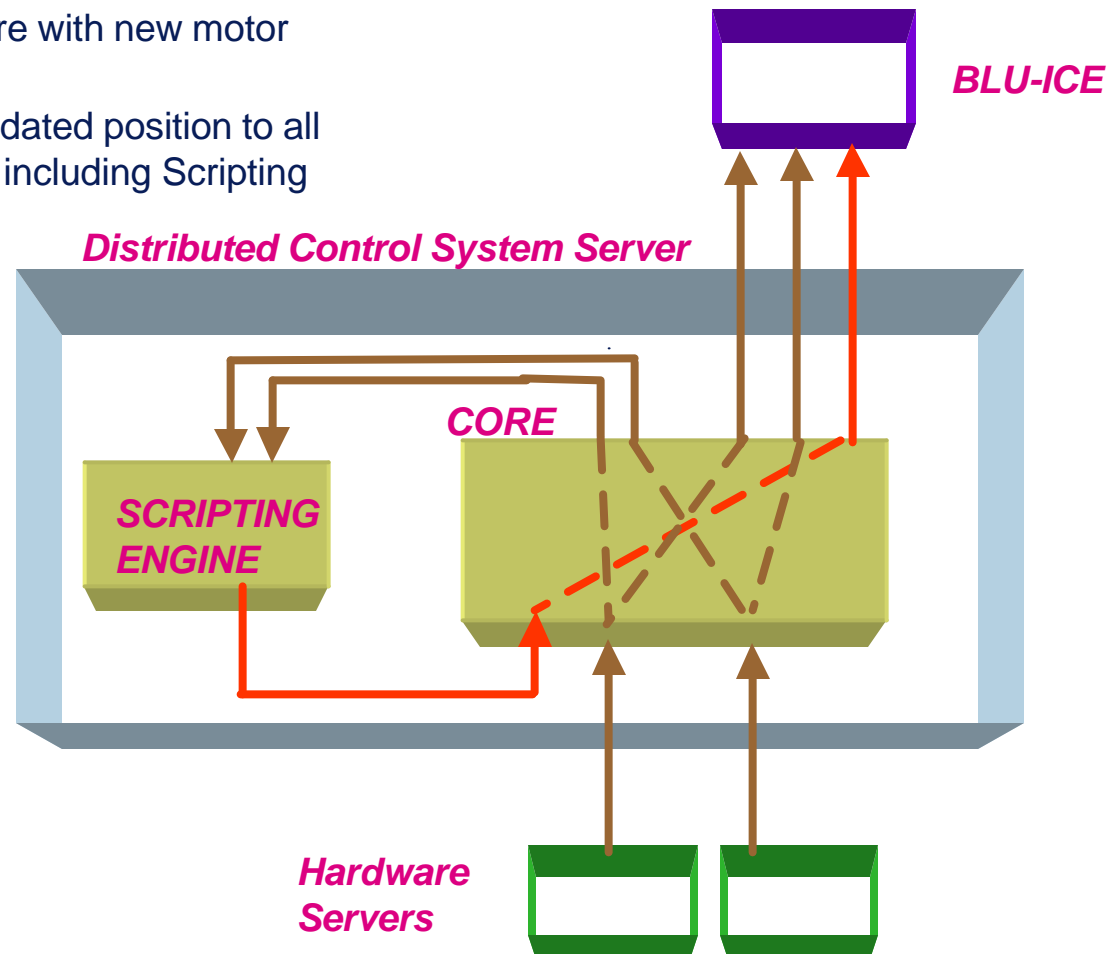
Scripted Devices: Path of a Response Message



- **Path of a Response Message**

- DHS updates DCSS core with new motor position.
- DCSS core forwards updated position to all "User Interface Clients" including Scripting Engine
- Scripting Engine realizes event has occurred on a child motor.
- Scripting Engine calculates new position of parent motor and sends messages back to DCSS core.
- DCSS core updates all "User Interface Clients"

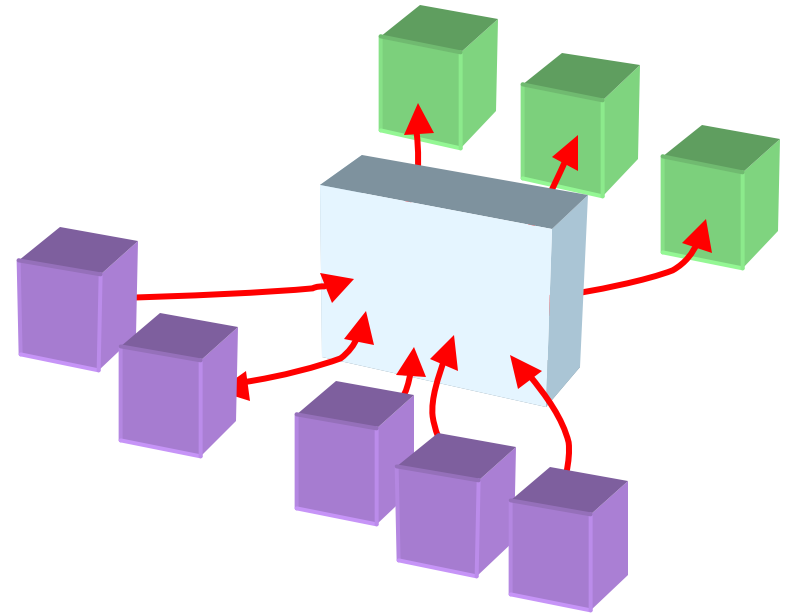
- **All parent and children devices are updated continuously.**



Conclusions



- **Cross platform development and XOS supports distributed systems and collaborative efforts**
 - Minimizes wasting of time with new OS's.
 - Easy to support new hardware.
 - Easy to use code in new environments.
- **Distributed architecture based on a central server simplifies implementation of powerful features.**
 - Synchronization of multiple GUI's.
 - Scripted device support that spans any number of low-level control systems.
- **Good tools save time**
 - TCL's event-based programming model and dynamic scripting capabilities have saved us hundreds of hours of work
 - Scripted device implementation would have been extremely difficult using other programming models.





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SSRL Director - Keith Hodgson
SMB Leader - Britt Hedman

The Macromolecular Crystallography Group

Mike Soltis
Peter Kuhn

Henry Bellamy
Aina Cohen
Ashley Deacon
Paul Ellis
Thomas Eriksson
Ana Gonzales
Mike Hollenbeck
Scott McPhillips
Tim McPhillips
Pavel Petrashen
Paul Phizackerley
Amanda Prado
Jere Rassai

